VOL. XXXIII JULY 1949 NO. 3

THE JOURNAL OF AGRICULTURE

of the

UNIVERSITY OF PUERTO RICO

THE UTILIZATION OF GRASSES, LEGUMES AND OTHER FORAGE CROPS FOR CATTLE FEEDING IN PUERTO RICO
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PUBLISHED BY
UNIVERSITY OF PUERTO RICO
THE AGRICULTURAL EXPERIMENT STATION
RÍO PIEDRAS, P. R.

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THE JOURNAL OF AGRICULTURE
OF THE UNIVERSITY OF PUERTO RICO

Issued quarterly by the Agricultural Experiment Station of the University of Puerto Rico, for the publication of articles by members of its personnel, or others, dealing with any of the more technical aspects of scientific agriculture in Puerto Rico or the Caribbean Area.

Vol. XXXIII July, 1949 No. 3

THE UTILIZATION OF GRASSES, LEGUMES AND OTHER FORAGE CROPS FOR CATTLE FEEDING IN PUERTO RICO

II. COMPARISON OF FERTILIZED GUINEA GRASS, PARA GRASS AND TROPICAL KUDZU AND TROPICAL KUDZU ALONE AS PASTURE CROPS

LUIS RIVERA BRENES,[1] FRANCISCO J. MARCHÁN[2] AND JOSÉ I. CABRERA[3]

INTRODUCTION

The improvement of the pasture and soiling crops is vital to the dairy cattle industry in Puerto Rico. The high importation of concentrate feeds which in 1947–1948 was around 6 million dollars (2) is due principally to the poor quality roughage consumed by our livestock. There is no doubt about the fact that there is no need for cattle, in general, consuming a high quality forage, especially grass-legume mixtures, to consume large quantities of concentrate feed in order to meet their requirements for maintenance, gain in weight, milk production and reproduction. This, at the same time, reduces the cost of production considerably because the cow has been fitted by nature to be an efficient user of roughage which is the cheapest part of the ration.

LITERATURE REVIEW

It was found in this Station (11) that heifers pasturing in a mixture of Para grass-Kudzu gained consistently more in weight than those that were pasturing in Para grass or Guinea grass alone. Significantly larger amounts of T.D.N. were also produced by the mixture; the carrying capacity was approximately 1 head per acre for the mixture; 1/2 for Para grass alone and 1/2 for Guinea grass alone. No fertilizer was applied in this experiment.

It was also found (11) that the grass growing with the legume had a higher protein content than when grown alone.

It has been proved that the use of fertilizer, especially nitrogenous

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fertilizer, besides increasing the total yield also increases the protein content of the grasses; thus improving the nutritive value and increasing the carrying capacity.

In South Africa, Weinman (15) found that fertilization increased the contents of N, P and K in the herbage, also the yield was augmented considerably. Lavvorn (9) found the response of Dallis and Carpet grasses to nitrogen fertilizer to be very great. The yields in pounds of air-dry matter per acre in a fine sandy loam were as follows:

	No Treatment	*Fertilized with N.P.K.*
Dallis	917.0 lbs.	2158.0 lbs.
Carpet	731.0 lbs.	1695.0 lbs.

To find out the effects and efficiency of nitrogen fertilization in sugar cane, Borden in Hawaii (4) used Para grass (*Panicum barbinode*) in pots as an indicator crop. He found that increasing the amount of nitrogen from 0.275 up to 2.2 grams per pot increased the dry weight from 119 to 337 grams as compared to 47 grams for no nitrogen. He also found that for each additional amount of nitrogen applied there is a corresponding decrease in efficiency that is usually associated with all growth factors, i.e., "the law of diminishing returns is operative and is true regardless the season during which the crop was grown." The efficiency was measured in grams of dry weight per gram of nitrogen.

The West Virginia Agricultural Experiment Station (12) reports the results of the tests for 10 grasses in the treatment of pastures with lime and fertilizer showing marked increases in carrying capacity. When nitrogen, phosphorus, potash and lime were applied they had increases from 112 per cent to 124.7 per cent. Irwin (8) in Alaska found that broadcasting 200 to 400 pounds of ammonium sulphate per acre or spreading manure at 6 to 8 tons per acre on grass meadows in the Spring at the beginning of the growing season more than doubled the yields of hay or pasture.

In Kansas (1) shortages of adapted brome grass seed were due primarily to the failure of brome grass stands to produce well after their 2nd. to 4th. year. Applications of nitrogen fertilizer supplying 75 to 100 pounds of nitrogen per acre corrected the unthrifty condition of the old brome grass sods and resulted in increased yields of both seed and forage. It was also found that protein percentage was increased materially. In North Dakota (14) they had the same problem with brome grass. They submitted a series of brome grass plots to the following treatments. 1—ammonium sulphage, 2—superphosphate, 3—a mixture of superphosphate and ammonium sulphate, 4—fresh barn yard manure and 5—cultivation alone. The study continued for three seasons and the influence of various treatments was measured by the number of seed heads produced and the yield of forage

compared with a check plot. During the third year nitrogen fertilizer had apparently increased the forage yield, and more when ammonium sulphate was used than when either manure or superphosphate was added. Manure had a very desirable residual effect.

Bartholomew (3) cites some examples of the capacity of non-leguminous grass crops to respond to nitrogen. In the Virginia Agricultural Experiment Station Orchard grass yields were increased from 1099 pounds an acre where no nitrogen was added to 5099 pounds when a hundred-weight of nitrogen was applied. The protein yields in pounds per acre in the two treatments were 99 and 528 pounds per acre respectively. In South Dakota the average yield of several adapted grasses from experiments in four counties was 1964 pounds an acre when no fertilizer was applied, 3093 pounds per acre when only nitrogen was used and 3240 pounds per acre when nitrogen was added along with phosphorus.

Sullivan (13) in his article about effects of fertilizers on herbage stated the following:

1. Fertilization influences the chemical composition of herbage in two ways:

a. favors the growth of some plants rather than others.

b. affects the quality of herbage by changing the chemical composition of individual plants.

2. Any effect of nitrogen fertilizer in increasing protein is usually apparent a short time only. In Connecticut, when it was applied to blue grass and bent grass in the Spring, only the first successive monthly cuttings showed greater protein contents than those from unfertilized areas. If high protein throughout the season is desired, the nitrogen must be applied frequently.

3. The more commonly applied fertilizers: nitrates, ammonium sulphate, phosphate and potash, and also lime, do promote an increase in one or more of the desirable major nutritive elements and thus, they improve forage quality. Weinmann (16) found that the dry matter yield from the fertilized, moderately grazed plots was significantly higher than that produced by any other treatment, the lowest yields being obtained from the unfertilized plots (control). Heavy grazing reduced significantly the herbage production when fertilizer was applied, but not in the unfertilized plots. The treatments and yields were the following.

Treatment	*Yield*
1. Moderately grazed and fertilized	8021 lbs. dry matter per acre
2. Moderately grazed and unfertilized	4473 lbs. dry matter per acre
3. Heavily grazed and fertilized	5851 lbs. dry matter per acre
4. Heavily grazed and unfertilized	4611 lbs. dry matter per acre
5. Control grazed and unfertilized	3541 lbs. dry matter per acre

The nutrient yields were highest in the fertilized moderately grazed plots. The application of fertilizer caused a considerable increase in the nutrient uptake under both grazing intensities. Fertilizer treatment produced, under both heavy and moderate grazing, a herbage of higher protein, phosphorus and potash content. The fertilizers used were 40 pounds of nitrogen, 120 pounds phosphoric acid anhydride and 40 pounds potash per 2.12 acres as first application, then 200 pounds of ammonium sulphate per 2.12 acres per season for three seasons. In California, Dickey (6) found that in an area of range representative of the 60,000,000 acres of land now devoted to grazing the application of ammonium phosphate-sulphate at the rate of 200 pounds per acre increased the production of hay from 1259 pounds to 3755 pounds per acre. He considered more important still that the range readiness of the fertilized plots was seven weeks earlier than the unfertilized plots.

From Holland, Riemsdyk (10) informs that the average crop of pasture may be estimated at 2500 Kg. starch value per hectare[4] or 3750 Kg. per hectare when grazed off. By application of 200 Kg. of nitrogen per hectare this latter figure might be increased to 5100 Kg. per hectare, and by improvement of the fields a further increase to 5500 Kg. may be expected.

Comparative digestibility trials with sheep were carried out by Ferguson (7) on hays top dressed with nitrogenous fertilizer 8 to 13 days before cutting and on similar untreated hays. One lot consisted of a mixture of Rye grass and cockfoot treated with ammonium sulphate while the other hay was a mixture of meadow grasses and a little wild white clover top dressed with Nitro chalk. An increase of 2 per cent of crude protein and 1.2 per cent of true proteins was produced by the treatment. The digestibility was significantly higher in the top dressed hays.

Brown (5), comparing legumes with grasses fertilized with nitrogen, for hay and pasture, stated that during a 5-year period the yields of timothy were increased markedly by both 28 and 56 pounds of nitrogen per acre annually; but in the same season, alfalfa on nearby plots unfertilized since seeding produced more dry matter and twice much more protein. Ladino clover-orchard grass seedings also yielded more dry matter and much more protein than a stand of timothy fertilized with 28 pounds of nitrogen in each of the months of April and June. The seeding of Ladino clover with either Kentucky blue grass or Rhode Island bent grass, land mowed 8 times per season for 7 years resulted in a larger total and better distributed yields than the application of nitrogen at 28 pounds per acre in each of the months of April, June and August on the grasses alone. On grazed permanent pastures spring applied nitrogen stimulated a 30 per cent increase in total yield over mineral fertilization.

[4] Hectare—2.5 acres.

Lavvorn (9), studying the effect of nitrogen fertilizer on legumes stated that apparently the use of nitrogen in legumes either depresses production or is of no benefit. The grass-legume combinations have the tendency to respond to nitrogen during the early stages, but once a satisfactory legume was established, regardless of whether it was a perennial as white clover or a winter annual as low top clover, the yields attained were as great from the mineral fertilizer as from the complete fertilizer.

PROCEDURE

The forage grasses used in this grazing trial were Guinea grass *Panicum maximum* Jacq, the mixture of Tropical Kudzu and Para grass *Pueraria phaseoloides Javanica* Benth, *Panicum purpurascens* Reddi and Tropical Kudzu.

The procedure was the same as that used in a previous trial (11) with some slight modifications. The grazing trial lasted 273 days (from December 18, 1946 to September 16, 1947), divided in three periods, according to the number of heifers in the grass plots. The first period of 115 days, with one heifer in each one-acre plot; the second of 48 days, with one heifer in each one-acre plot of Para-Kudzu and Kudzu and two heifers in each one-acre plot of Guinea grass, and the third period of 110 days, with two heifers in each one-acre plot of Para-Kudzu and Guinea grass and one heifer in each one-acre plot of Kudzu.

Following recommendations of the Soils and Agronomy Departments on November 18, 1946, one month before the beginning of the trial, 1000 pounds of 10-10-5 fertilizer per acre were applied to the Guinea grass in addition to 167 pounds of muriate of potash. To the following sub-plots[5] of Kudzu 167 pounds of superphosphate were added.

1. Block A—Sub-plot 3
2. Block B—Sub-plot 1
3. Block C—Sub-plot 2

Superphosphate at the same rate was applied also to the following Para grass-Kudzu sub-plots.

1. Block A—Sub-plot 2
2. Block B—Sub-plot 1
3. Block C—Sub-plot 3

[5] As explained before (11) each acre plot was divided into three ⅓ acre sub-plots for the rotation. The blocks were A, B and C, so the sub-plots were numbered A-1, 2 and 3; B- 1, 2 and 3, etc.

On February 10, 1947 another application of 200 pounds of ammonium sulphate per acre was made to the Guinea grass and then on June 4 another application of the same kind and amount of nitrogenous fertilizer.

A group of Holstein, Native and Native-Holstein heifers were used. To avoid breed differences the heifers were distributed among the grasses in the following way; one Holstein, one Native and one Native-Holstein in each grass, legume and legume-grass combination.

RESULTS AND DISCUSSION

Weight gains by period are presented in Table 1.

Although the heifers in the mixture plots gained more in the first two periods there is not much difference between the groups.

Since the mixture plots did not receive any nitrogenous fertilizer and they yielded practically the same as the grass which had received fertilizer, the superiority of the mixture and the legume over the grass is obvious.

The average chemical analysis for all the samples taken during the grazing trial are presented in table 2.

The protein content of the mixture and of Kudzu was more or less the same as in the previous trial (11) but the average crude protein content of Guinea grass under this fertilized condition was 8.56 as compared to 5.76 before; an increase of 2.80 per cent.

To see the immediate effect of the application of nitrogenous fertilizer on the analysis of Guinea grass, three samples, one from each acre plot, were taken one month after the application on February 10, 1947. These analyses were compared with those of three samples of the Para-Kudzu mixture taken on the same date. The results are presented in table 3.

The average analysis of crude protein for these particular Guinea grass samples is much higher than the over all average, while that for the mixture plots is a little lower.

The above results might explain the importance of the legume-grass mixtures for feeding purposes. The beneficial effects on the soil and on the grass exerted by the legume are more uniform and more permanent bringing with it a more uniform nutrient intake by the animals being grazed on it.

Nitrogenous fertilizer has an immediate effect on the analysis but after some time the grass comes back to what we can call, its normal condition for the kind of soil, clearly seen in the average analyses presented in table 2 of this and the previous trial (11). This is of great importance when the grass is to be used for soilage or for silage.

The total amount of clippings and dry matter content in pounds is shown in Table 4.

Larger amounts of clippings for the first period were as expected because

TABLE 1

Weight gains in pounds per group, mean gain per animal and least significant difference

Grasses	No. of heifers	Initial weight of group	Weight of group at end of period	Gains of groups in pounds	Mean gain in wgt. in lbs. per animal
First Period 12-18-46 to 4-11-47					
PK*	3	958.00	1495.33	538.00	179.33
K	3	911.00	1315.67	404.67	134.89
G	3	1041.67	1480.33	438.66	146.22
Least sign. diff. 5%					48.41
1%					80.29
Second Period 4-12-47 to 5-29-47					
PK	3	1495.33	1690.67	195.34	65.11
K	3	1315.67	1525.67	210.00	70.00
G	6	2609.33	2903.33	294.00	49.00
Least sign. diff. 5%					26.89
1%					39.78
Third Period 5-30-47 to 9-16-47					
PK	6	3166.33	3904.00	737.67	122.95
K	3	1525.67	1903.34	377.34	125.89
G	6	2903.33	3708.33	805.00	134.17
Least sign. diff. 5%					44.00
Between PK and K 1%					54.59
Least sign. diff. 5%					35.96
Between PK and G 1%					44.61

* PK = Para grass-Kudzu mixture
K = Kudzu alone
G = Guinea grass

TABLE 2

Average analysis of the three forage crops during the whole trial in per cent, dry basis

Grasses	No. of samples	Moisture %	Ash %	Crude Protein %	Fat %	Fiber %	N.F.E. %
Para-Kudzu	33	75.8	7.60	10.05	1.87	32.43	47.38
Kudzu	15	79.59	6.39	18.94	3.07	31.73	39.88
Guinea grass	33	76.21	8.63	8.56	2.04	33.42	46.76

the plots rested for some time and when the heifers were put on them there was a rank growth in all. Some heifers grazed up their sub-plots first, or like in Kudzu alone the amount of roughage was much less than in the other grass plots causing frequent changes which permitted larger amounts of clippings in the Guinea and Para grass-Kudzu sub-plots when all the heifers were moved.

The larger amount of clippings from the Guinea grass plots all through the entire duration of the grazing trial was probably due to the fertilization.

Except for the first period, no residue was clipped from the Kudzu plots, the reasons of which will be discussed farther ahead.

TABLE 3

Average analysis of Guinea grass, samples taken 1 month after application of nitrogenous fertilizer and of the mixture of Para grass-Kudzu, samples taken the same date

Grasses	Moisture %	Ash %	Crude Protein %	Fat %	Fiber %	N.F.E. %
Guinea	77.43	9.65	13.24	3.30	32.10	41.80
Para grass-Kudzu	72.16	7.95	9.38	2.13	34.01	46.53

TABLE 4

Clippings and dry matter content in pounds by periods

	First period		Second period		Third period	
Grass	lbs. Clippings	lbs. Dry matter	lbs. Clippings	lbs. Dry matter	lbs. Clippings	lbs. Dry matter
PK	10155.00	2457.51	475.00	114.95	544.00	131.65
K	385.00	78.66	00.00	00.00	00.00	00.00
G	29288.00	6967.62	1081.00	257.17	1102.00	262.17

Data and calculation of total nutrients and carrying capacity is presented in table 5.

The carrying capacity shown by Guinea grass in this trial more than double the results obtained in the previous experiment (11). The rise was exactly from 0.42 to 1.21 due, with all probability, to the nitrogen applications. The mixture of Para grass-Kudzu had more or less the same carrying capacity as before, about one head per acre. Kudzu planted alone, in spite of its high nutritive value, had a carrying capacity of only 0.47.

Although the nutritive value of Guinea grass as shown by the average chemical analysis and the gain in weight of the heifers was lower than that for Para grass-Kudzu mixture the amount of roughage produced made it possible for it to have a little higher carrying capacity.

TABLE 5

Calculation of total digestible nutrients and carrying capacity for the three periods of the experiment

Items	First period			Second period			Third period		
	PK	K	G	PK	K	G	PK	K	G
1. Days in period	115	115	115	48	48	48	110	110	110
2. Number of heifers	3	3	3	3	3	6	6	3	6
3. Total heifer days (1) × (2)	345	345	345	144	144	288	660	330	660
4. Total initial weight in lbs.	958.00	911.00	1041.67	1495.33	1315.67	2609.33	3166.33	1525.67	2903.33
5. Total final weight in lbs.	1495.33	1315.67	1480.33	1690.67	1525.67	2303.33	3904.00	1903.34	3708.33
6. Average maintenance, lbs. $\frac{(4)+(5)}{2}$	1226.67	1113.33	1261.00	1593.00	1420.67	2756.33	3535.17	1714.51	3305.83
7. Total weight days (6) × (1)	141067.05	128032.95	145015.00	76464.00	68192.16	132303.84	388868.70	188506.10	363641.30
8. TDN for maintenance $\frac{(7) \times 7.925}{1000}$	1117.96	1014.64	1149.28	605.98	540.12	1048.51	3081.79	18859.10	2881.85
9. Weight gain in pounds	538.00	405.00	439.00	195.34	210.00	294.00	737.67	1494.66	805.00
10. TDN requirement for gain in lbs. (9) × 3.53	1899.14	1429.65	1549.67	689.55	741.30	1037.82	2603.98	377.67	2641.65
11. TDN requirements, pounds (8) + (10)	3017.10	2444.29	2698.25	1295.55	1281.72	2086.33	5685.77	1333.18	5723.50
12. TDN from residue, pounds	1769.40	56.63	5016.68	82.76	—	185.16	94.79	2827.84	188.75
13. TDN yield of pasture, pounds (11) + (12)	4768.50	2500.92	7715.63	1378.29	1281.72	2271.49	5780.52	2827.84	5912.26
14. TDN yield per acre $\frac{(13)}{\text{acreage}}$	1595.50	883.64	2571.88	459.43	427.24	757.16	1926.84	942.61	1970.75
15. Standard cow-days per acre $\frac{(14)}{(16)}$	99.72	55.23	160.74	28.71	26.70	47.32	120.43	58.91	123.17
16. Carrying capacity standard cow-days $\frac{(15)}{(1)}$	0.87	0.48	1.40	0.60	0.56	0.99	1.09	0.54	1.12

Numbers in parenthesis indicates item number

The analysis of the calculated total digestible nutrient yields is presented in table 6.

Both Para grass-Kudzu mixture and Guinea grass were superior to Kudzu alone in total digestible nutrient yields all through the three periods. Total digestible nutrients produced by Guinea grass during the first and second

TABLE 6

Mean total digestible nutrient yields per acre and least significant differences for the grass for the three periods

Grasses	Total digestible nutrient mean yields in lbs. per acre
First period	
PK	1595.00
K	833.00
G	2572.00
Least sign. difference 5%	381.00
1%	632.82
Second period	
PK	459.33
K	427.66
G	757.00
Least sign. difference 5%	168.53
1%	279.75
Third period	
PK	2020.33
K	988.00
G	2058.33
Least sign. difference 5%	308.55
1%	511.73

periods were higher than the amount produced by the legume grass mixture; the difference being highly significant. During the third period although Guinea grass produced 38 pounds more total digestible nutrients the difference was not significant. This indicates with all probability that by this time the grass was not receiving the effects of the nitrogen fertilizers as during the previous periods. This is sustained also by the results obtained for carrying capacity for this period. It also agrees with Sullivan

(13), who stated that the effect of nitrogen fertilizer is usually apparent for a short time only.

Abundant rain fell during the entire experimental period. Table 7 shows the precipitation by months.

In general, the water supply was adequate.

The uniformity of growth response to grazing and the nutritive value of the mixture of Para grass-Kudzu has been shown by the results of this and previous trials. Except for a small amount of superphosphate to some of the sub-plots no other fertilizer was applied considering that the application of nitrogen depresses the growth of the legume. (See literature review.) There is no doubt that the mixture of Para grass and Kudzu is very desirable for grazing animals.

TABLE 7

*Precipitation from December 1946 to September 1947 in inches**

Month	*Inches of rainfall*
December 1946	6.85
January 1947	7.71
February 1947	5.76
March 1947	1.38
April 1947	2.82
May 1947	10.24
June 1947	4.24
July 1947	1.88
August 1947	11.20
September 1947	12.22
Total	64.30

* Records kept at the Experiment Station farm.

Although Guinea grass grows fairly well in the northern part of the Island, it is typical of the dry fertile lands of the South.

In the North the soil is relatively poor and acid and Guinea grass gets sod bound after two or three years. This same thing happens to brome grass in Kansas and North Dakota. (See literature review.) Applications of nitrogen have corrected this condition. This indicates that in order to maintain Guinea grass always in good condition in this region of the Island, applications of nitrogen at constant intervals is necessary. Such management is quite costly and unnecessary if we consider that the introduction of a legume will correct the situation.

Tropical Kudzu is a very nutritive legume as shown by the chemical analysis and by the gains in weight of the animals that grazed on it. In combination with grass it is also very good, as shown by the results of this

and a previous trial. However, this legume has certain characteristics that have been observed which are not desirable when planted alone. These observed characteristics are the following:

1. It must be seeded during the rainy season, as it requires abundant moisture.

2. It is very slow in getting established, requiring 6 to 8 months for a good stand.

3. When grazed, the amount of forage produced is low because of a very slow recovery. This was responsible for too frequent changes to the next sub-plot in order to avoid over-grazing. This was also responsible for the lack of residue to be clipped from it after the changes and, of course, this lowered the carrying capacity.

4. Kudzu alone does not withstand much trampling, and many times the places where the animals slept could be noticed after three or four weeks.

5. During the months from November to February, when the days are shorter and the temperature is milder, very little growth is obtained from Kudzu. During this time weeds take advantage. Another factor which contributes to this retardation is that this legume blooms beginning at late November through December and seed matures during February.

SUMMARY AND CONCLUSIONS

A second grazing trial was conducted using the same procedure of the first except that nitrogenous fertilizer was applied to Guinea grass. This time the three roughages compared were Para grass-Kudzu, Kudzu alone and Guinea grass.

The performance of Para grass-Kudzu mixture was as uniform as in the previous trial; the carrying capacity being around one head per acre. The results obtained with fertilized Guinea grass more than doubled the results in the previous trial where no fertilizer was used. Besides an increase in forage, there was also an increase in protein content. The carrying capacity increased from 0.42 to 1.12 heads per acre. Kudzu had a lower carrying capacity than the mixture with Para grass and Guinea grass.

The conclusions arrived at in relation to the mixture of Para grass-Kudzu in the previous trial were verified by the results of this experiment. The uniformity in performance and high quality forage more than recommends the use of this combination for grazing, especially in the humid section of the northern part of the Island.

Guinea grass is a well known forage crop, principally in the grazing area of the South. Under normal conditions, with no fertilization, it is low in protein content. Fertilization increased the protein and doubled the yield but farmers must take into consideration the cost of the fertilizer and that

fertilization has only an immediate effect on the grass needing new applications at certain intervals to maintain that condition. In contrast, legumes do have a more permanent effect on the soil and the grasses growing with them. This makes them recommendable. Adapted legume grass mixtures are no more expensive to establish and are cheaper than grasses alone from all points of view.

The planting of Kudzu alone is not to be recommended.

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EFFECT OF NITROGEN APPLICATIONS ON THE YIELDS AND COMPOSITION OF FORAGE CROPS

JUAN PASTOR RODRÍGUEZ

INTRODUCTION

The livestock industry is the second most important agricultural enterprise of Puerto Rico. Milk is a most important item in the diet of the Puerto Rican families, especially, for the feeding of children, but we are not producing enough milk so that the population can have an ample supply of this important item.

There are many factors which might increase the production of milk in Puerto Rico, and among them is the improvement of the production and quality of green forage. This is the most important item in the daily ration of the dairy cow. Most of the grasses used in the feeding of livestock in the Island are relatively low in protein content, thus large amounts of imported concentrates, high in protein, must be used by the dairy industry to maintain the milk production at an adequate level.

The chemical composition of the foliage of any crop, however, is not constant, but varies with the climate, the capacity of the soil to provide the crop with the nutrients it needs in sufficient amounts, the age of the plant and other factors. In turn, the capacity of a soil to provide a crop with sufficient amount of the nutrients it requires may be altered by making fertilizer and soil amendments to the soil. The determination of the proper time of applying nitrogen to soils, deficient in this element, would undoubtedly be of help in the improvement of yield per acre and quality of the forage crops, thus increasing the efficiency of the dairy industry.

Several experiments leading to this end were recently conducted at Río Piedras. The procedures employed and results obtained are described in this article.

The work reported here has been carried out in our main Station farm at Río Piedras, over the period from 1945 to 1948, with the three most important forage grasses, namely, Guinea, Merker and Para-Carib.

Guinea, *Panicum maximum* Jacq., is principally a pasture grass on both the North and South coasts, but occasionally it is cut and fed green. It is native of Africa, and according to E. D. Colón (4) its introduction dates from the early part of the XVI century. It is said that the seed of this grass was first introduced to Puerto Rico in the straw used for bedding of human cargoes of slave ships from Africa. Hitchcock (7) describes it as follows: "Perennial; culm cespitose, erect, 1 to 2.5 m tall, glabrous; the nodes densely hirsute; blades flat, elongate, 1 to 3.5 cm. wide, glabrous,

except the margin, or hirsute on the upper surface near the base: panicle open, 20 to 50 cm. long, the lower branches in whorls; spikelets oblong, glabrous, about 3 mm. long; first glume one-third as long as spikelets; fruit transversely rugose. Found in the open ground, at low altitudes, escaped from cultivation, southern Florida, through Mexico and the West Indies to South America. To be found on all the islands of the West Indies."

Merker, *Pennisetum purpureum* var. *Merkerii* Schumaker, has come into favor for green forage in the dairy farms of Puerto Rico. This is really a fine stemmed strain of Napier grass of which a selected variant was introduced to Puerto Rico by this Agricultural Experiment Station, from McNeill Branch Experiment Station, McNeill, Mississippi, in the year 1934. Only a few seed pieces were received for a start, but the propagation was easy and it is now on nearly every farm in the Island. Besides being practically immune to the *Helminthosporium* leaf spot, it is a high yielder and has high nutritive value. The environmental requirements for its best development are more or less the same as for Napier grass. Both Merker and Napier require a rich soil for best growth. Under favorable conditions they produce enormous amounts of green forage and can be cut several times during the year.

Para-Carib—These two grasses grow in association in Puerto Rico, and in the vicinity of Río Piedras, where this work was conducted, they are inseparably mixed. Very few dairymen or farmers speak of Carib grass, they always talk of the Para grass being the most important grass for the dairy cows. But since these two grasses have been found so mixed in ordinary culture and as it was thought to be rather impracticable to separate them for ordinary planting, it was decided to call Para-Carib the grass mixture in our experimental plots, rather than Para or Carib alone. They certainly differ from one another in some respects. Para grass or "malojillo", *Panicum purpurascens* Raddi, (7) is a straggling perennial forming a tangled mass along the banks of streams or ditches. It is similar to Carib grass in general appearance but may be distinguished from the latter by the thicker more succulent stems (Alberts and García Molinari) (1), and its larger leaves that are light-green in color. Para or "malojillo", blooms from October to December, while Carib grass blooms throughout the year. During the non-blooming period, Para grass can be distinguished in the field from Carib grass by its hairy non-flowering stem that projects several inches above the stems of the Carib grass.

The Carib grass, "malojilla", *Eriochloa polystachya* H.B.K., resembles Para grass (Hitchcock), but differs in the spikelet characters. This grass grows in the same habitat as does Para grass and they are frequently found growing in association. It appears to have the same forage value as Para grass. In the continental United States the name used is Carib grass.

REVIEW OF LITERATURE

The work presented here deals with the influence of nitrogen treatments on the yield and composition of forage grasses. No attempt has been made, therefore, to cover the literature along the line of forage production and management.

Pasture and forage grasses, almost everywhere, seem to be rather low in protein content, therefore, increasing attention has been given to the improvement of their yield and composition.

Brown (2), at the Storrs Experiment Station in Connecticut, in summing up his five-year work on the effect of various fertilizer treatments on the seasonal production of permanent pastures, states that: "Although the total production has been increased by fertilization, none of the treatments has affected very markedly the proportion of the total feed produced in a given part of the season. During the 5 years of 1927–31, the mineral plus nitrogen plots produced 252 feed units (17%) per acre per year more than the plots receiving mineral only. Of this difference in favor of nitrogen, over two-thirds was produced during the zenith period, May 15, June 15, and the remainder before May 15. Applying one-half of the nitrogen in July, rather than all in April, has resulted in slightly less total feed, but in about 8% more grazing during the late summer months."

Brown and Munsell (3) in Connecticut, in comparing the yield and quality of several grasses fertilized with nitrogen for hay and pasture with legume and legume-grass mixture report a high increase in total yield as stimulated by nitrogen over the mineral fertilization. In this respect the authors state: "On grazed permanent pastures, spring-applied nitrogen stimulated a 30% increase in total yield over mineral fertilization. Most of the addition growth occurred before June 16. Spring and summer nitrogen resulted in less May, but more summer feed than from applying all the nitrogen in April. The most uniform seasonal distribution of pasturage was obtained by adding nitrogen only in the summer, but the returns per unit of nitrogen were about half those from the spring treatment."

Macfarland (8) in England, in his work on time of application of nitrogen as a factor influencing the yield of herbage on permanent pastures, found an immediate and significant increase in yield. He reported that the rainfall affected considerably the yields obtained. But, as regards nitrogen, he found that the percentage recovery of nitrogen was high, varying from 54 to 83 per cent.

Woodman, Evans, and Oosthuizen (12) at Cambridge, England, working on the influence on yield and composition of a single heavy dressing of sulphate of ammonia as compared with that of a small dressing throughout the season, showed that one heavy application will give as high a yield as a

similar amount of sulphate of ammonia applied in small amounts during the same season.

Dodd (6) in Ohio, experimenting with nitrogen fertilizer on Kentucky blue grass pasture, found that grass treated with nitrogen fertilizer becomes more palatable to the extent that the cattle grazed it more closely than grasses in adjoining areas which had no nitrogen. The time of application in Dodd's work showed results as follows: "Early spring application of nitrogen fertilizer increased the production in the early spring and also throughout the season. Making a second or third application of nitrogen later in the season materially increased the fall growth. The exact time of response in extra growth resulting from nitrogen treatments appeared to be dependent upon the moisture and temperature conditions."

It was found by Munsell and Brown (10) in Connecticut, that when single applications of nitrogen are made in April they produce its greatest effect in May, after which the nitrogen content fell rapidly and remained low for the rest of the season, but, that when the fertilizer was withheld until June or August, the highest point in total nitrogen for the season was attained in the succeeding cuttings. The application of 56 pounds of nitrogen was required to reach this high point.

As to amount and frequency of applications, Munsell and Brown (10), found that 14 pounds of the nitrogen fertilizer applied six times during the season, produced practically the same increase in average nitrogen content over no treatment as three applications of 28 pounds, and that the fluctuations were less when the applications were made six times per season. A further increase was obtained when 56 pounds of nitrogen were applied three times (116 pounds per season) to Kentucky bluegrass (0.39%) and to Rhode Island grass (0.32%).

As regard the influence of intensive fertilizing on the yield and composition of good permanent pasture, *Woodman* and *Underwood* (12) in England, found the main part of the improvement during the early period of the season. They concluded that the soil of good permanent pasture is capable of supplying assimilable nitrogen at a sufficiently rapid rate to meet the demands for proteins synthesis in the herbage plants, and that only when plants are growing very rapidly, as they do early in the season, are they unable to secure the supplies of nitrogen at a rate consistent with their maximum ability for building up the new protein. At this stage, therefore, the addition of readily available nitrogen to the soil is reflected in a stimulation of the rate of growth. They also found that dressings of sulphate of ammonia caused a slight improvement in the crude protein content of the herbage during the first year of application, the effect being most marked in April and October, but that during the second season of the experiment, however, this improvement was not manifested. *Woodman, Evans* and

Oosthuizen (13) in England, who carried out work on the influence on yield and composition of a single dressing of sulphate of ammonia compared with that of periodic small dressings throughout the season, point out that favorable weather conditions should prevail at the time of application for an efficient utilization of the nitrogen fertilizer. They found very pronounced stimulation of early growth and unusually high crude protein content by applying a heavy dressing of sulphate of ammonia to grassland in February under *suitable weather conditions*. They emphasize that for efficient utilization of an early and heavy application of the sulphate of ammonia the weather conditions at this period of the year must be especially favorable. It has the advantage of encouraging early growth without risk of "scorching" the grasses, and then the additional light dressings, when applied at intervals during the summer months, are effective in the stimulation of growth when the grass normally tends to be scarce. A single heavy application made in the month of February does not extend to these later stages of the summer season.

Colwell and Tisdale (5) in "A summary of the most recent works on nitrogen fertilization" note that: "Studies involving the time of application of nitrogen have not been confined to the United States. Numerous foreign investigators have shown that applying nitrogen in several amendments, instead of in one application, has led not only to increased yields but to increased quality of grain and forage. This increase in quality is reflected in larger amounts of protein. Ranking has likewise shown that the time of application of nitrogen has a marked effect on the yield and quality of wheat under North Carolina conditions. He was also able to show that if lack of growth was caused by insufficient nitrogen applied before April, this effect was manifested throughout the remainder of the season in yield and nitrogen content of the plants."

The foregoing facts indicate that the time and method of placement of nitrogen in relation to soil type and environment are important factors in the proper nutrition of plants.

EXPERIMENTAL METHODS

The experimental field was located in the main Station farm at Río Piedras, Puerto Rico. The soil was a Vega Baja Silty Clay of medium fertility which had been planted to sugar cane seedlings for several years.

Roberts (11) has described this type of soil as follows: "*Vega Baja Silty clay.*"—Vega Baja silty clay is the most extensive soil of the Vega Baja series. It occurs in a number of widely separated parts of the humid section, where it occupies bordering or intergrade areas between the alluvial soils and the coastal-plain soils. It lies above normal overflow, but during exceptionally high water it is flooded. The surface soil to a depth of 8 or 10 inches

is friable light brown or grayish-brown granular acid silty clay loam. This layer changes abruptly to a plastic medium-compact mottled yellowish-brown, gray, and red silty clay or clay subsoil, which continued to considerable depth and becomes slightly more definitely mottled and more acid with depth. Vega Baja silty clay has slightly better natural drainage than Vega Baja clay. It is not so productive as the clay, however, because the soil is more compact and the plant roots can not penetrate it so readily for a supply of plant nutrients and moisture as they can the wet subsoil of Vega Baja clay. Areas associated with the Estación soils have deeper and browner surface soils than typical areas. In some places the mottled subsoil lacks the real color. The texture of the surface soil also varies from place to place, ranging from silty loam to silty clay predominating."

The field was divided into three experimental lots, one for each of the three grasses used in this work. Each lot was then sub-divided into 40 one-hundredth acre plots, each plot 20 feet by 21.78 feet, containing ten rows, 20 feet long. The layout of the experimental field was a randomized block. With five treatments, replicated eight times.

In the first part of this work the nitrogen applications were made as described below. Sulphate of ammonia was used as the only source of nitrogen.

Treatment	*Rate of Nitrogen Application*	*Time of Applications*
A	No nitrogen	.....
B	50 pounds NH_3 per acre	Immediately after planting or harvesting.
C	50 pounds NH_3 per acre	Three weeks after planting or harvesting.
D	50 pounds NH_3 per acre	Six weeks after planting or harvesting.
E	50 pounds NH_3 per acre	Nine weeks after planting or harvesting.

Nitrogen applications were made, in the form described above, to the three grasses: namely, Guinea grass, Merker grass and Para-Carib grass. The grasses were cut and allowed to ratoon four times at intervals of 12 weeks. Two 500-gram samples of each green grass were taken at each harvest and immediately sent to the laboratory for determination of nitrogen and dry matter.

In the second part of this work the procedure was altered and the nitrogen applications were made as follows:

Treatment A. No nitrogen applied (Control).

Treatment B. Nitrogen applied at the rate of 200 pounds Sulphate of Ammonia (equivalent to 50 pounds nitrogen per acre).

1. Immediately after harvesting for Merker.
2. Three weeks after harvesting for Guinea.
3. Six weeks after harvesting for Para-Carib.

Treatments C, D and E. One-half of the amount of nitrogen applied under treatment B on the same day of application as for B, followed by a similar application nine weeks after harvesting.

Treatment C. Harvested one week after the second application of nitrogen.

Treatment D. Harvested two weeks after the second application of nitrogen.

Treatment E. Harvested three weeks after the second application of nitrogen.

As in the first part of the work, grass samples (500 grams) were taken for the determination of nitrogen and dry matter. The grass samples were weighed in the field of harvest and immediately placed in bags and sent to the laboratory.

The experimental data were carefully recorded and the statistical analyses were made soon after each harvest.

EXPERIMENTAL DATA

The data obtained clearly indicate that nitrogen applications greatly increase the yield and protein content of our most important forage grasses (Tables 1, 4, 5, 6, 7, 9, 11 and 13): Guinea *Panicum maximum* Jacq.; Merker *Pennisetum purpureum* Schumaker, var. *Merkerii*, and the mixture of Para *Panicum purpurascens* Raddi., and Carib *Eriochloa polystachia* H.B.K. The yield of green forage and protein of the grasses which received nitrogen were always more than double the yield of the control plots. It was also demonstrated that the time of application of the nitrogen (in the form of $(NH_4)_2SO_4$) had an influence on both yield and composition of the grasses, (tables 3 and 4) but that the best time of application for yield was not the best time of application for maximum protein content.

Accordingly, the procedure of the experiments was altered, thus in this second part of the work results were somewhat different. Both Guinea and Merker grasses showed that applying all the fertilizer (200 pounds sulphate of ammonia per acre) at one time resulted in a maximum production of dry forage and protein, but different results (tables 8, 9, 10, 11, 12 and 13) were obtained with the Para-Carib grass, which gave maximum yields when splitting the amount of nitrogen used, and applying half of it six weeks after cutting, and the remainder, nine weeks later. But, as regards mean nitrogen contents of the grasses in per cent dry matter, all three grasses (Guinea, Merker and Para-Carib) had a higher nitrogen content when they received the fertilizer nitrogen split in two applications and the grasses were cut at ten weeks intervals, and a lower nitrogen content when they received all the nitrogen at one time and the grasses were cut at 12 weeks intervals (tables 14, 15 and 16). It seems that when nitrogen is ap-

TABLE 1

Mean green forage yields in cwts. per acre and significant differences in six cuts of Guinea, Merker and Para-Carib grasses

		Treatments					Least significant differences	
		A	B	C	D	E		
Grass Name	No. of Cut	No fertilizer applied	Fertilizer applied immediately after planting or cutting	Fertilizer applied 3 weeks after planting or cutting	Fertilizer applied 6 weeks after planting or cutting	Fertilizer applied 9 weeks after planting or cutting	At the 5% point	At the 1% point
Guinea, *Panicum maximum* Jacq.	2	80.38	215.75	215.38	163.63	168.25	19.65	26.51
	3	80.50	200.63	201.88	185.00	188.75	15.85	21.39
	4	118.50	220.63	296.63	254.63	203.38	12.62	17.03
	5	35.00	178.00	194.00	175.00	127.00	14.38	19.11
	6	76.00	113.00	135.00	118.00	111.00	12.82	17.30
	7	52.00	152.00	138.00	134.00	105.00	9.83	13.26
Mean		73.75	180.06	196.90	171.77	150.60	15.00	20.00
Merker, *Pennisetum purpureum* Schum. var. *Merkerii*	2	80.13	237.88	167.25	151.50	146.75	25.21	34.01
	3	144.75	305.88	300.00	275.00	300.38	53.76	72.53
	4	183.50	340.50	335.50	297.25	289.88	44.15	59.57
	5	121.00	221.00	216.00	206.00	187.00	33.17	44.75
	6	58.00	159.00	159.00	140.00	134.00	35.24	47.55
	7	86.00	198.00	166.00	157.00	131.00	35.18	47.47
Mean		112.13	243.83	224.13	198.33	204.60	37.79	51.76
Para, *Panicum purpurascens* Raddi, and Carib grass *Eriochloa polystachya* H.B.K.	2	20.75	60.88	41.63	49.63	44.75	14.28	19.27
	3	39.38	82.13	104.13	121.38	104.88	27.67	37.33
	4	63.63	174.75	144.50	139.50	151.50	37.89	51.12
	5	91.00	156.00	189.00	189.00	152.00	16.40	21.72
	6	65.00	157.00	196.00	167.00	142.00	15.77	21.28
	7	43.00	116.00	116.00	117.00	64.00	27.14	36.61
Mean		53.69	117.79	131.69	129.65	106.88	29.75	39.47

TABLE 2

Mean dry matter yields and significant differences in six cuts of Guinea, Merker and Para-Carib grasses

Grass Name	No. of Cut	Treatments A: No fertilizer applied	B: Nitrogen applied immediately after planting or cutting	C: Nitrogen applied 3 weeks after planting or cutting	D: Nitrogen applied 6 weeks after planting or cutting	E: Nitrogen applied 9 weeks after planting or cutting	Least significant differences: At the 5% point	At the 1% point
Guinea, *Panicum maximum*, Jacq.	2	21.3	57.9	57.3	41.8	43.5	6.70	9.04
	3	20.4	51.3	50.6	44.6	42.3	4.27	5.78
	4	31.8	64.3	85.6	64.4	51.8	4.04	5.42
	5	20.8	54.4	59.1	47.5	32.3	5.82	7.85
	6	9.5	28.1	37.9	31.6	27.9	5.04	6.78
	7	15.8	47.5	42.4	38.1	30.3	3.93	5.30
Mean		19.90	50.57	55.50	44.67	37.98	7.78	10.50
Merker, *Pennisetum purpureum* Schum var. *Merkerii*	2	15.9	57.8	35.9	29.6	30.1	11.16	15.07
	3	26.8	63.1	60.9	51.4	50.4	11.33	15.28
	4	48.0	90.4	92.4	72.9	71.5	14.79	19.95
	5	28.1	63.6	66.9	53.4	43.9	12.31	16.61
	6	12.6	44.9	41.6	33.8	29.1	10.10	13.62
	7	19.9	48.3	37.4	35.4	31.9	9.11	12.30
Mean		25.33	61.33	55.67	46.00	43.23	14.97	20.20
Para, *Panicum purpurascens* Raddi and Carib grass *Eriochloa polystachya*, *H.B.K.*	2	7.0	20.1	13.7	15.2	14.3	3.87	5.22
	3	10.9	25.1	30.0	32.4	27.9	8.25	11.13
	4	17.4	41.0	37.0	36.1	41.0	11.59	15.64
	5	20.9	42.8	60.6	61.8	39.4	7.84	10.58
	6	15.4	40.6	51.8	39.1	30.6	5.65	7.63
	7	12.9	33.9	32.3	30.0	18.0	8.87	11.96
Mean		14.04	33.90	37.54	35.75	28.52	6.48	7.90

TABLE 3

Mean nitrogen content percent dry matter and significant differences between mean nitrogen in six cuts of Guinea, Merker and Para-Carib grasses

Grass Name	No. of Cut	Treatments A: No nitrogen applied	B: Nitrogen applied immediately after planting or cutting	C: Nitrogen applied 3 weeks after planting or cutting	D: Nitrogen applied 6 weeks after planting or cutting	E: Nitrogen applied 9 weeks after planting or cutting	Least significant differences: At the 5% point	At the 1% point
Guinea, *Panicum maximum* Jacq.	2	0.74	0.67	0.73	0.78	0.80	0.06	0.09
	3	0.74	0.73	0.78	0.83	1.24	0.08	0.11
	4	0.96	0.81	0.95	1.05	1.35	0.12	0.16
	5	0.83	0.79	0.79	0.97	1.06	0.14	0.19
	6	0.95	0.86	0.89	1.09	1.21	0.07	0.09
	7	0.75	0.73	0.79	0.95	0.98	0.06	0.08
Mean		0.83	0.76	0.82	0.94	1.11	0.13	0.16
Merker *Pennisetum purpureum* Schum., var. *Merkerii*	2	0.63	0.67	0.78	0.74	0.90	0.08	0.11
	3	1.04	0.92	0.95	1.04	1.32	0.12	0.17
	4	0.90	0.80	0.89	1.11	1.24	0.14	0.18
	5	1.04	0.94	1.06	1.21	1.33	0.09	0.13
	6	1.10	1.02	1.06	1.16	1.45	0.12	0.16
	7	0.91	0.93	1.01	1.04	1.12	0.10	0.14
Mean		0.95	0.88	0.95	1.05	1.23	0.11	0.15
Para (malojillo) Panicum *purpurascens* Raddi, and Carib (malojilla) *Eriochloa polystachya* H.B.K.	2	0.83	0.74	0.74	0.87	0.94	0.12	0.17
	3	1.31	1.23	1.29	1.39	1.74	0.14	0.18
	4	1.32	1.24	1.20	1.29	1.68	0.14	0.19
	5	1.28	1.25	1.20	1.34	1.75	0.24	0.32
	6	1.42	1.32	1.21	1.40	1.76	0.20	0.27
	7	1.15	1.08	1.26	1.34	1.41	0.10	0.13
Mean		1.22	1.14	1.15	1.27	1.55	0.14	0.19

TABLE 4

Mean protein yields in pounds per acre and significant differences in six cuts of Guinea, Merker and Para-Carib grasses

Grass Name	No. of Cut	Treatments A (CHECK) No fertilizer applied	B Fertilizer applied immediately after planting or cutting	C Fertilizer applied 3 weeks after planting or cutting	D Fertilizer applied 6 weeks after planting or cutting	E Fertilizer applied 9 weeks after planting or cutting	Least significant differences At the 5% point	At the 1% point
Guinea, *Panicum maximum*, Jacq.	2	98.0	242.5	259.3	205.4	220.4	31.12	41.98
	3	93.5	232.4	244.4	230.5	326.0	26.56	35.84
	4	189.4	323.6	508.3	421.8	428.4	51.43	69.38
	5	107.5	266.6	289.4	286.9	208.0	32.91	44.40
	6	56.9	151.8	211.3	215.8	210.4	36.47	49.21
	7	73.9	216.4	210.5	226.1	184.5	25.31	34.15
Mean		103.19	238.88	287.17	264.40	264.60	44.07	59.46
Merker, *Pennisetum purpureum* Schum. var. *Merkerii*	2	67.4	249.6	173.6	138.1	167.9	53.90	72.72
	3	174.8	369.6	365.5	331.0	434.8	85.20	114.94
	4	276.9	459.4	516.6	508.9	547.3	124.76	168.32
	5	183.4	374.4	441.1	404.6	346.6	82.41	111.18
	6	92.1	287.9	280.6	239.1	263.9	81.80	110.35
	7	112.0	274.5	237.0	228.9	223.1	59.13	79.77
Mean		151.08	335.90	335.75	308.44	330.58	73.41	99.02
Para, *Panicum purpurascens* Raddi and Carib grass (Malojilla) *Eriochloa polystachya* H.B.K.	2	36.4	94.3	62.5	83.4	87.1	30.58	41.25
	3	88.1	188.0	239.1	285.3	301.8	76.72	103.50
	4	144.3	296.5	277.6	292.6	431.8	106.52	143.70
	5	169.6	336.9	453.5	516.9	433.9	91.87	123.95
	6	137.8	337.5	396.0	326.8	336.8	79.61	107.40
	7	93.1	228.6	246.9	247.5	162.1	82.98	111.96
Mean		111.54	246.96	279.27	292.06	292.23	87.65	118.26

TABLE 5

Mean green forage yields in cwts. per acre, and significant differences in four cuts of Guinea grass

Grass Name	No. of Cut	No nitrogen applied	200 lbs. of ammonium sulfate applied all at one time	100 lbs. ammonium sulfate applied *three weeks after* cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Harvested at 12 week intervals	Harvested at 12 week intervals	Harvested at 10 week intervals	Harvested at 11 week intervals	Harvested at 12 week intervals	At the 5% point	At the 1% point
Guinea *Panicum maximum* Jacq.	1	68.13	178.13	108.88	104.50	137.13	11.44	15.44
	2	46.50	155.88	113.63	124.63	121.25	10.42	14.06
	3	95.88	284.00	165.25	140.75	226.00	16.39	22.11
	4	63.50	191.25	142.30	189.50	144.25	10.59	14.28
Mean		68.50	202.31	138.22	139.84	157.16	16.92	22.82

TABLE 6

Mean green forage yields in cwts. per acre, and significant differences in four cuts of Merker grass

Grass Name	No. of Cut	No nitrogen applied	200 lbs. of ammonium sulfate applied all at one time	100 lbs. ammonium sulfate applied immediately after cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Harvested at 12 week intervals	Harvested at 12 week intervals	Harvested at 10 week intervals	Harvested at 11 week intervals	Harvested at 12 week intervals	At the 5% point	At the 1% point
Merker, *Pennisetum purpureum* Schum. var. *Merkerii*	1	115.00	244.10	152.30	166.10	172.00	27.44	37.02
	2	89.00	197.50	157.13	158.63	156.50	18.24	24.61
	3	136.00	283.00	175.00	166.00	251.00	22.43	30.27
	4	98.40	176.50	149.90	193.00	150.30	15.77	21.28
Mean		109.56	225.34	158.50	171.00	182.53	30.71	41.43

TABLE 7

Mean green forage yields in cwts. per acre and significant differences in four cuts of Para-Carib grass

Grass Name	No. of Cut	No nitrogen applied	200 lbs. of ammonium sulfate per acre applied all at one time	100 lbs. of ammonium sulfate per acre applied six weeks after cuting and 100 lbs. applied 9 weeks after cutting.			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Harvested at 12 week intervals	Harvested at 12 week intervals	Harvested at 10 week intervals	Harvested at 11 week intervals	Harvested at 12 week intervals	At the 5% point	At the 1% point
Para or "mallojillo" *Panicum purpurascens*, Raddi, and Carib grass or "malojilla" *Eriochloa polystachya* H.B.K.	1	52.90	120.60	78.40	125.50	117.80	11.86	16.00
	2	28.75	69.75	109.00	112.25	70.00	23.43	31.61
	3	57.88	159.60	122.50	162.50	153.75	21.38	28.85
	4	49.50	63.60	99.50	153.50	116.40	9.77	13.18
Mean		47.25	103.38	102.34	139.31	114.47	55.10	74.34

TABLE 8

Mean dry forage yields in cwts. per acre and significant differences in four cuts of Guinea grass, Panicum maximum Jacq.

No. of Cut	Treatment A No fertilizer applied (CHECKS)	Treatment B Nitrogen applied at the rate of 50 lbs. NH_3 per acre 3 weeks after cutting all at one time	Nitrogen applied at the rate of 25 lbs., NH_3 *3 weeks after* cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
			Treatment C	Treatment D	Treatment E		
	Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
1	16.9	43.0	23.0	26.1	32.3	3.55	4.79
2	12.0	42.9	30.9	29.0	32.5	3.64	4.91
3	25.6	76.3	31.8	30.6	54.9	16.55	22.33
4	16.4	56.9	32.4	55.4	42.3	11.83	15.94
Mean	17.72	54.75	29.81	35.28	40.47	10.49	14.15

TABLE 9

Mean protein content in the dry matter in lbs. per acre, and significant differences in four cuts of Guinea grass, Panicum maximum Jacq.

	Treatment A No fertilizer applied (CHECKS)	Treatment B Nitrogen applied at the rate of 50 lbs. NH_3 per acre 3 weeks after cutting all at one time	Nitrogen applied at the rate of 25 lbs., NH_3 *3 weeks after* cutting and 25 lbs. applied 9 weeks after cutting			Least significant differences	
			Treatment C	Treatment D	Treatment E		
No. of Cut	Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
1	94.5	266.0	154.5	186.4	224.5	28.49	38.43
2	71.4	264.8	214.4	185.5	200.1	31.03	41.86
3	110.5	325.0	246.3	200.8	273.8	78.62	106.07
4	66.5	214.4	236.5	352.5	153.8	77.92	105.13
Mean	85.72	267.53	212.91	231.28	213.03	63.74	85.99

TABLE 10

Average dry forage yields in cwts. per acre and significant differences in four cuts of Merker grass, Pennisetum purpureum Schum. *var. Merkerii*

	Treatment A No fertilizer applied (CHECKS)	Treatment B Nitrogen applied at the rate of 50 lbs. NH_3 per acre all at one time immediately after cutting	Nitrogen applied at the rate of 25 lbs. NH_3 immediately after cutting and 25 lbs. applied 9 weeks after cutting			Least significant differences	
			Treatment C	Treatment D	Treatment E		
No. of Cut	Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
1	22.3	45.75	28.88	23.3	30.60	10.47	14.12
2	20.4	44.30	32.10	33.5	38.30	5.98	8.07
3	29.8	70.40	31.10	31.9	58.50	5.96	8.04
4	28.4	52.40	30.00	47.9	46.80	6.47	8.73
Mean	24.44	49.91	30.53	35.38	43.53	10.26	13.85

TABLE 11

Mean protein content in the dry matter in pounds per acre and significant differences in four cuts of Merker grass, Pennisetum purpureum Schum. *var. Merkerii*

No. of Cut	Treatment A No fertilizer applied (CHECKS)	Treatment B Nitrogen applied at the rate of 50 lbs. NH_3 per acre all at one time immediately after cutting	Nitrogen applied at the rate of 25 lbs. NH_3 immediately after cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
			Treatment C	Treatment D	Treatment E		
	Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
1	143.6	281.9	204.9	206.4	216.1	73.09	98.61
2	150.1	303.1	250.0	253.6	289.3	51.02	68.83
3	166.0	429.0	258.0	243.3	395.4	99.04	133.62
4	164.8	348.0	284.9	389.5	319.6	44.48	60.01
Mean	156.13	340.40	251.69	273.19	305.09	69.14	93.28

TABLE 12

Mean dry forage yields in cwts., per acre and significant differences in four cuts of Para-Carib grass

Grass Name	No. of Cut	No Nitrogen applied	$(NH_4)_2SO_4$ at the rate of 200 lbs. per acre applied all at one time	$(NH_4)_2SO_4$ at the rate of 100 lbs. per acre six weeks after cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Harvested at 12 week intervals	Harvested at 12 week intervals	Harvested at 10 week intervals	Harvested at 11 week intervals	Harvested at 12 week intervals	At the 5% point	At the 1% point
Para grass or "malojillo" *Panicum purpurascens* Raddi and Carib grass "malojilla" *Eriochloa Polystachya* H.B.K.	1	11.53	32.88	19.50	26.25	29.75	4.14	5.58
	2	9.13	19.62	27.63	28.38	15.88	5.45	7.35
	3	13.88	34.50	33.63	27.13	33.63	4.38	5.91
	4	14.75	19.38	21.75	40.63	34.25	3.69	4.97
Mean		13.28	26.59	22.38	30.59	28.38	5.47	7.38

TABLE 13

Average protein content in the dry matter in pounds per acre and significant differences in four cuts of Para-Carib grass

Grass Name	No. of Cut	No Nitrogen applied	$(NH_4)_2SO_4$ at the rate 200 lbs. per acre applied all at one time	$(NH_4)_2SO_4$ at the rate of 100 lbs. per acre six weeks after cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Harvested at 12 week intervals	Harvested at 12 week intervals	Harvested at 10 week intervals	Harvested at 11 week intervals	Harvested at 12 week intervals	At the 5% point	At the 1% poiet
Para grass or "malojillo" *Panicum purpurascens* Raddi and Carib grass "malojilla" *Eriochloa Polystachya* H.B.K.	1	112.4	256.1	169.6	301.5	270.9	52.26	70.51
	2	73.5	168.0	431.8	288.3	171.9	147.23	198.63
	3	85.4	217.0	268.4	325.4	289.1	67.69	91.32
	4	108.5	127.0	280.0	425.4	220.9	41.10	55.45
Mean		94.94	192.03	287.44	335.13	238.19	121.32	163.67

TABLE 14

Mean nitrogen contents percent dry matter and significant differences between mean yields in four cuts of Guinea grass

Grass Name	No. of Cut	No Nitrogen	200 lbs. of ammonium sulfate per acre applied all at one time	100 lbs. of ammonium sulfate per acre applied *three weeks* after cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
Guinea, *Panicum maximum*, Jacq.	1	0.89	0.98	1.07	1.13	1.11	0.07	0.10
	2	0.96	0.97	1.14	1.02	1.00	0.10	0.13
	3	0.68	0.68	1.24	1.05	0.80	0.11	0.15
	4	0.65	0.60	1.12	1.01	0.71	0.20	0.27
Mean		0.80	0.81	1.14	1.05	0.91	0.13	0.17

TABLE 15

Mean nitrogen contents percent dry matter and significant differences between mean yields in four cuts of Merker grass

Grass Name	No. of Cut	No nitrogen applied	200 lbs. of ammonium sulfate per acre applied all at one time	100 lbs. of ammonium sulfate per acre applied immediately after cutting and 100 lbs. applied 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
Merker, *Pennisetum purpureum* Schum. var. *Merkerii*	1	1.03	0.99	1.14	1.18	1.13	0.10	0.14
	2	1.17	1.10	1.29	1.21	1.25	0.10	0.13
	3	0.92	0.84	1.33	1.23	1.08	0.11	0.15
	4	1.05	1.05	1.51	1.31	1.10	0.35	0.47
Mean		1.04	1.00	1.32	1.23	1.14	0.076	0.102

TABLE 16

Mean nitrogen contents percent dry matter and significant differences in four cuts of Para-Carib grass

Grass Name	No. of Cut	No Nitrogen applied	200 lbs. of ammonium sulfate per acre applied all at one time	100 lbs. of ammonium sulfate per acre applied six weeks after cutting and 100 lbs. 9 weeks after cutting			Least significant differences	
		Treatment A	Treatment B	Treatment C	Treatment D	Treatment E		
		Cut at 12 week intervals	Cut at 12 week intervals	Cut at 10 week intervals	Cut at 11 week intervals	Cut at 12 week intervals	At the 5% point	At the 1% point
Para grass or "malojillo" *Panicum purpurascens*, Raddi, and Carib grass *Eriochloa polystachya* H.B.K.	1	1.18	1.25	1.37	1.80	1.45	0.15	0.21
	2	1.27	1.37	1.88	1.57	1.47	0.15	0.20
	3	1.02	1.04	2.07	1.93	1.35	0.22	0.30
	4	1.19	1.04	2.09	1.68	1.04	0.51	0.69
Mean		1.17	1.17	1.90	1.74	1.33	0.15	0.24

plied there is a more or less rapid assimilation of the nitrogen by the grass depending on the soil moisture, season of the year, and size of the plant, until a maximum content of nitrogen is attained. During this period the intake of nitrogen exceeds its utilization by the plant in forming new tissues. The maximum content probably occurs when these two processes are in equilibrium. Thereafter, the rate of utilization of nitrogen exceeds its rate of absorption, with a consequent reduction in per cent of dry matter. If enough time elapses, the nitrogen content per cent dry matter of the grasses fertilized with nitrogen may be reduced through growth to about the same level as that of the unfertilized grasses. This may be seen on comparing the nitrogen content of the grasses grown under treatment A (control) and treatment B, when all the nitrogen was applied at one time at the start of the growth cycle (tables 14, 15 and 16). As stated above, cutting the grasses at 12-weeks intervals gave higher yields of dry forage and protein per acre than cutting the grasses at 10-week intervals, in the case of Guinea and Merker grasses (tables 8, 9, 10 and 11). Maximum yields of dry forage and protein were obtained when the Para-Carib was cut at 11-week intervals (tables 12 and 13). But as regard statistical differences, in the case of Guinea grass there were no significant differences between yields of dry forage and protein produced by grasses cut at 12 and 10-week intervals (Tables 8 and 9). Merker grass had a significant difference at the 5% point (Tables 10 and 11). Para-Carib grass produced higher yields of dry forage and protein when cut at 11-week intervals, than at 12 and 10-week intervals (Tables 12 and 13) but as regard the statistical differences were found that there were no significant differences between the protein produced, when cut at 12 and 10-week intervals, and protein produced when the grass was cut at 11-week intervals.

The age of the grasses has to do with their palatability, thus the cattle will eat it more readily when its palatability is improved. These facts lead to the conclusion that splitting the amount of nitrogen to be applied in two equal portions for two applications, and cutting the grass at 10-week intervals will give us forage of superior quality, with a high protein content and of greatest palatability.

CONCLUSIONS

The yield of green forage and protein of our most important forage grasses is greatly increased by the application of nitrogen at the rate of fifty pounds of ammonia per acre.

When the nitrogen is applied all at one time and the grasses are cut at 12-week intervals, the maximum yield of green forage was obtained when the Guinea grass received the fertilizer 3 weeks after planting, Merker

grass immediately after planting, and the Para-Carib six weeks after planting.

When the nitrogen is applied all at one time and the grasses are cut at 12-week intervals the maximum nitrogen content of the grasses was obtained when all the grasses received the nitrogen nine weeks after planting.

When the nitrogen was applied splitting the amount used and applying one-half the amount at the time each grass gave maximum yields of green forage, and one-half the amount nine weeks after cutting, maximum nitrogen content of the grasses was obtained when they were cut at 10-week intervals.

When the application of all the nitrogen at one time was compared to the application of nitrogen splitting the amount in two equal portions, the maximum yield of dry forage and protein occurred when the Guinea and Merker grasses were cut at 12-week intervals with all the fertilizer applied at once, and when the Para-Carib received one-half of the nitrogen six weeks after harvest and one-half nine weeks after cutting and the grass was harvested at 11-week intervals.

Good quality forage can be obtained by splitting the fertilizer to be applied into two equal portions for two applications and cutting the grass at 10-week intervals. This forage will have both a high protein content and good palatability.

SUMMARY

This work gives useful information for the practical farmer. The production of green forage for feeding livestock, especially for dairy cattle, can be improved by the application of nitrogenous fertilizer at the proper time and in sufficient quantity to three important forage grasses. By the proper use of this information, green grasses high in protein can be made available in more ample quantities in the dairy farms of the Island than they are at present. That is, the dairy farmers could actually raise or maintain better pastures and a larger number of heads of cattle than are now raised on the land used for pasture.

Considering that Puerto Rico is very hard pressed for good agricultural lands, the possibility of increasing the production of animal products in the land now available for this purpose becomes of greatest importance.

In addition, with proper management of their pasture or silage grasses, dairy farmers can cut down on their expenses for concentrated feeds by increasing the protein content of their grasses.

ACKNOWLEDGMENT

The writer expresses his indebtedness to Dr. Bernardo G. Gapó, Assistant Director for Research, without whose constant encouragement and helpful

criticism and advice this work could not have been undertaken. The writer also thanks Mrs. Socorro G. Urrutia of the Soils Department for carrying out the determinations of nitrogen and dry matter of the grass samples.

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